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O'SHAUGHNESSY RESERVOIR, DELAWARE COUNTY, OHIO

PACIFIC NORTHWEST ENVIRONMENTAL RESEARCH
LABORATORY

PREPARED FOR
NATIONAL ENVIRONMENTAL RESEARCH CENTER

JUNE 1975

177053

PB 254 054

U.S. ENVIRONMENTAL PROTECTION AGENCY
NATIONAL EUTROPHICATION SURVEY

WORKING PAPER SERIES

PACIFIC NORTHWEST ENVIRONMENTAL RESEARCH LABORATORY

An Associate Laboratory of the

NATIONAL ENVIRONMENTAL RESEARCH CENTER - CORVALLIS, OREGON

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NATIONAL ENVIRONMENTAL RESEARCH CENTER - LAS VEGAS, NEVADA

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NATIONAL TECHNICAL
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U. S. DEPARTMENT OF COMMERCE
SPRINGFIELD, VA. 22161

0—697-032

TECHNICAL REPORT DATA
(Please read Instructions on the reverse before completing)

1. REPORT NO.	2.	3. RECIPIENT'S ACCESSION NO. PB254054
4. TITLE AND SUBTITLE Report on O'Shaughnessy Reservoir, Delaware County, Ohio		5. REPORT DATE Prepared June, 1975 6. PERFORMING ORGANIZATION CODE
7. AUTHOR(S) Anonymous (National Eutrophication Survey Staff)		8. PERFORMING ORGANIZATION REPORT NO. Working Paper # 407
9. PERFORMING ORGANIZATION NAME AND ADDRESS National Eutrophication Survey U.S. Environmental Protection Agency 200 S. W. 35th St. Corvallis, Oregon 97330		10. PROGRAM ELEMENT NO. 11. CONTRACT/GRANT NO.
12. SPONSORING AGENCY NAME AND ADDRESS Office of Research and Development U.S. Environmental Protection Agency 401 M Street, S. W. Washington, DC 20460		13. TYPE OF REPORT AND PERIOD COVERED Final - 1973 14. SPONSORING AGENCY CODE

15. SUPPLEMENTARY NOTES
Prepared in cooperation with the U.S. Environmental Protection Agency, National Environmental Research Center, Las Vegas, Nevada 89114

16. ABSTRACT

Annual total phosphorus and total nitrogen loadings to the lake were estimated and subdivided according to either point or non-point source origin. An assessment of the lake's trophic condition and limiting nutrient is also provided. All data collected by the U.S.E.P.A. National Eutrophication Survey during the one year study of the lake and its tributaries are included in the report.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group
Eutrophication Lakes nutrients phosphorus nitrogen loading		05B 05C

PRICES SUBJECT TO CHANGE

18. DISTRIBUTION STATEMENT	19. SECURITY CLASS *(This Report)*	21. NO. OF PAGES
Release unlimited		43
	20. SECURITY CLASS *(This page)*	22. PRICE
		$ 4.00

EPA Form 2220-1 (9-73)

REPORT
ON
O'SHAUGHNESSY RESERVOIR
DELAWARE COUNTY
OHIO
EPA REGION V
WORKING PAPER No. 407

WITH THE COOPERATION OF THE
OHIO ENVIRONMENTAL PROTECTION AGENCY
AND THE
OHIO NATIONAL GUARD

JUNE, 1975

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FOREWORD

The National Eutrophication Survey was initiated in 1972 in response to an Administration commitment to investigate the nationwide threat of accelerated eutrophication to fresh water lakes and reservoirs.

OBJECTIVES

The Survey was designed to develop, in conjunction with state environmental agencies, information on nutrient sources, concentrations, and impact on selected freshwater lakes as a basis for formulating comprehensive and coordinated national, regional, and state management practices relating to point-source discharge reduction and non-point source pollution abatement in lake watersheds.

ANALYTIC APPROACH

The mathematical and statistical procedures selected for the Survey's eutrophication analysis are based on related concepts that:

a. A generalized representation or model relating sources, concentrations, and impacts can be constructed.

b. By applying measurements of relevant parameters associated with lake degradation, the generalized model can be transformed into an operational representation of a lake, its drainage basin, and related nutrients.

c. With such a transformation, an assessment of the potential for eutrophication control can be made.

LAKE ANALYSIS

In this report, the first stage of evaluation of lake and watershed data collected from the study lake and its drainage basin is documented. The report is formatted to provide state environmental agencies with specific information for basin planning [§303(e)], water quality criteria/standards review [§303(c)], clean lakes [§314(a,b)], and water quality monitoring [§106 and §305(b)] activities mandated by the Federal Water Pollution Control Act Amendments of 1972.

Beyond the single lake analysis, broader based correlations between nutrient concentrations (and loading) and trophic condition are being made to advance the rationale and data base for refinement of nutrient water quality criteria for the Nation's fresh water lakes. Likewise, multivariate evaluations for the relationships between land use, nutrient export, and trophic condition, by lake class or use, are being developed to assist in the formulation of planning guidelines and policies by EPA and to augment plans implementation by the states.

ACKNOWLEDGMENT

The staff of the National Eutrophication Survey (Office of Research & Development, U. S. Environmental Protection Agency) expresses sincere appreciation to the Ohio Environmental Protection Agency for professional involvement, to the Ohio National Guard for conducting the tributary sampling phase of the Survey, and to those Ohio wastewater treatment plant operators who provided effluent samples and flow data.

Ned Williams, Director, and Tom Birch, Ken Carr, Larry Dietrick, Ron Havlice, Larry Korecko, Rod Mehlhop, Terry Wheeler, and John Youger, Ohio Environmental Protection Agency, provided invaluable lake documentation and counsel during the Survey, reviewed the preliminary reports, and provided critiques most useful in the preparation of this Working Paper series.

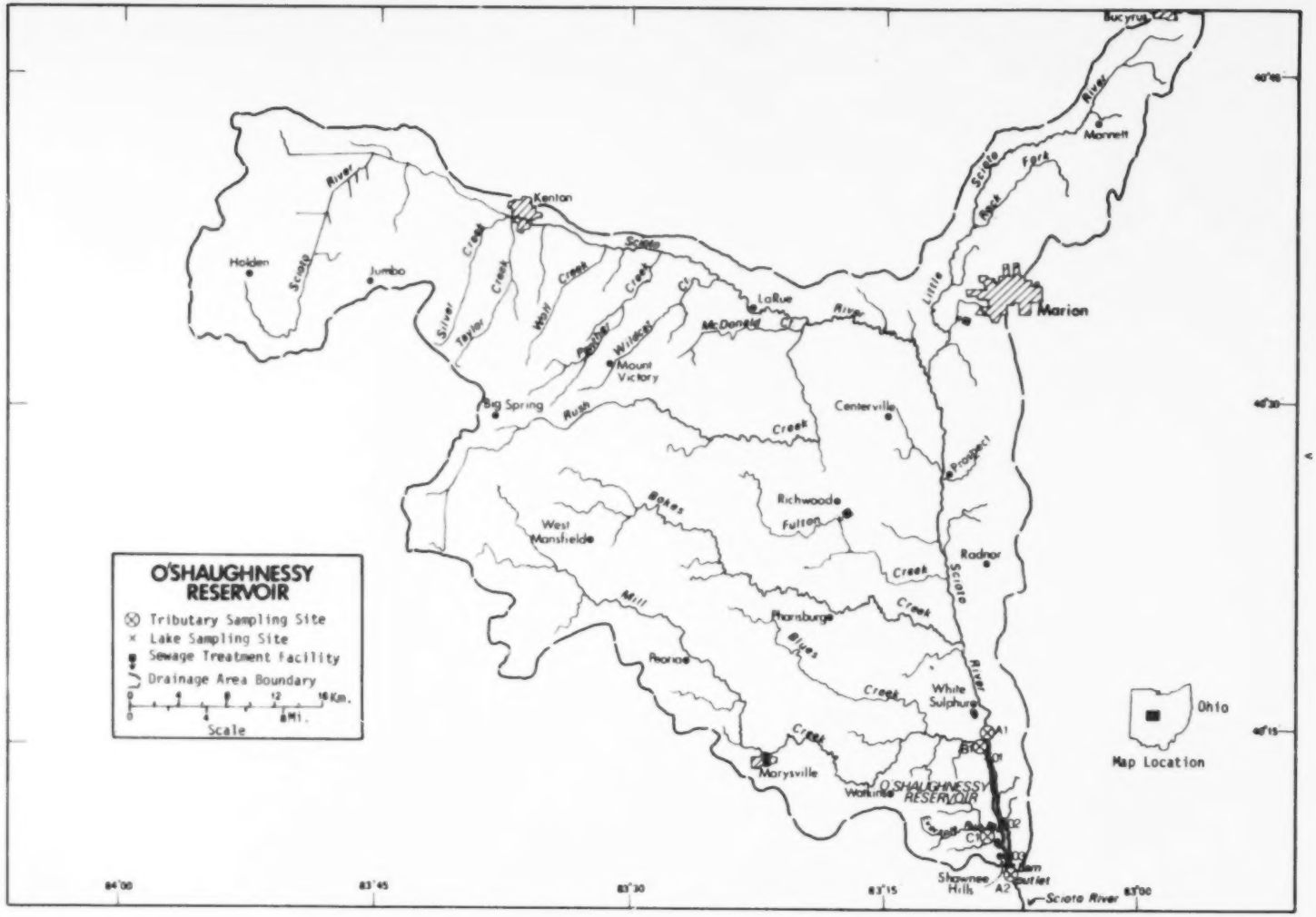
Major General Dana L. Stewart, then the Adjutant General of Ohio, and Project Officer Lt. Colonel Robert C. Timmons, who directed the volunteer efforts of the Ohio National Guardsmen, are also gratefully acknowledged for their assistance to the Survey.

NATIONAL EUTROPHICATION SURVEY

STUDY LAKES

STATE OF OHIO

LAKE NAME	COUNTY
Atwood	Carroll, Tuscarawas
Beach City	Stark, Tuscarawas
Berlin	Mahoning, Portage, Stark
Buckeye	Fairfield, Licking, Perry
Charles Mill	Ashland, Richland
Deer Creek	Fayette, Pickaway
Delaware	Delaware
Dillon	Muskingum
Grand Lake of St. Marys	Auglaize, Mercer
Grant	Brown
Holiday	Huron
Hoover	Delaware, Franklin
Indian	Logan
Loramie	Auglaize, Shelby
Mosquito Creek	Trumbull
O'Shaughnessy	Delaware
Pymatuning	Ashtabula, OH; Crawford, PA
Pleasant Hill	Ashland, Richland
Rocky Fork	Highland
Shawnee	Greene
Tappan	Harrison


O'SHAUGHNESSY RESERVOIR
Tributary Sampling Site
Lake Sampling Site
Sewage Treatment Facility
Drainage Area Boundary
Scale
Ohio
Map Location
Kenton
Holden
Jumbo
Marion
Mount Victory
Big Spring
Centerville
Richwoode
Fulton
West Mansfield
Radnor
Pharisburg
White Sulphur
Marysville
Shawnee Hills
Scioto River
Bucyrus
Marrett
LaRue
Prospect

O'SHAUGHNESSY RESERVOIR

STORET NO. 3931

I. CONCLUSIONS

A. Trophic Condition:

Survey data indicate that O'Shaughnessy Reservoir is eutrophic. It ranked last when the 20 Ohio lakes sampled in 1973 were compared using a combination of six parameters*. Nineteen lakes had less median total phosphorus, median dissolved phosphorus, and inorganic nitrogen. However, none of the lakes had less mean chlorophyll a, and 10 had greater mean Secchi disc transparency. Marked depression of dissolved oxygen with depth occurred at stations 2 and 3 in August and October.

Survey limnologists noted macrophytes along much of the shorelines near the sampling sites.

B. Rate-Limiting Nutrient:

The algal assay results are not indicative of reservoir conditions at the time the sample was collected (04/26/73) because of nutrient losses during shipment of the sample from the field to the laboratory. The reservoir data indicate phosphorus limitation during the spring and summer (April 26, 1973, and August 2, 1973); i.e., the mean N/P ratios were 20/1 or greater. However, the October data indicate that the reservoir was limited by nitrogen at the time; i.e., the mean N/P ratio was 6/1.

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* See Appendix A.

C. Nutrient Controllability:

1. Point sources--The total phosphorus contribution of the listed point sources accounted for 24.5% of the total load reaching O'Shaughnessy Reservoir during the Survey sampling year. The major contributors were the wastewater treatment facilities at Marion and Marysville which accounted for 18.5% and 4.8% of the total, respectively. The phosphorus export rate of the Scioto River (see page 13) was substantially higher than the 56 $kg/km^2/yr$ export of the Olentangy River, tributary to nearby Delaware Reservoir*, and it is likely that point sources outside of the 40-kilometer limit of the Survey** (e.g., Kenton) contributed significantly to the phosphorus load in the Scioto River and/or the phosphorus contribution of the City of Marion was underestimated. In any case, it is probable that the point-source contribution of phosphorus was greater than estimated in this report.

The present phosphorus loading of 70.73 $g/m^2/yr$ is nearly 27 times greater than that proposed by Vollenweider (Vollenweider and Dillon, 1974) as a eutrophic loading (see page 13). However, the mean hydraulic retention time of O'Shaughnessy Reservoir is a very short nine days, and Vollenweider's model probably does not apply. Nonetheless, the existing trophic condition of the reservoir is evidence of excessive nutrient loads, and all point source phosphorus loads should be minimized to the greatest practicable extent to at least slow the present rate of eutrophication

* See Working Paper No. 399, "Report on Delaware Reservoir".
** See Working Paper No. 175, "...Survey Methods, 1973-1976".

of O'Shaughnessy Reservoir.

2. Non-point sources--The phosphorus contribution of non-point sources was 75.5% of the total input to O'Shaughnessy Reservoir during the sampling year. The Scioto River contributed 64.5% of this total, Mill Creek contributed 10.4%, and Eversole Run contributed 0.2%. Ungaged tributaries and immediate drainage were estimated to have contributed a total of 0.4%.

II. LAKE AND DRAINAGE BASIN CHARACTERISTICS†

A. Lake Morphometry††:

1. Surface area: 3.35 kilometers^2.
2. Mean depth: 4.8 meters.
3. Maximum depth: >15.5 meters.
4. Volume: 16.080 x 10^6 m^3.
5. Mean hydraulic retention time: 9 days (based on outflow).

B. Tributary and Outlet:
(See Appendix C for flow data)

1. Tributaries -

Name	Drainage area (km^2)*	Mean flow (m^3/sec)*
Scioto River	1.994.3	18.1
Mill Creek	463.6	4.2
Eversole Run	28.0	0.3
Minor tributaries & immediate drainage -	46.3	0.5
Totals	2,532.2	23.1

2. Outlet -

Scioto River	2,535.6**	21.5

C. Precipitation***:

1. Year of sampling: 112.6 centimeters.
2. Mean annual: 92.5 centimeters.

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† Table of metric equivalents--Appendix B.
†† Youger, 1975.
* For limits of accuracy, see Working Paper No. 175, "...Survey Methods, 1973-1976".
** Includes area of lake.
*** See Working Paper No. 175.

III. LAKE WATER QUALITY SUMMARY

O'Shaughnessy Reservoir was sampled three times during the open-water season of 1973 by means of a pontoon-equipped Huey helicopter. Each time, samples for physical and chemical parameters were collected from three stations on the reservoir and usually from a number of depths at each station (see map, page v). During each visit, a single depth-integrated (4.6 m or near bottom to surface) sample was composited from the stations for phytoplankton identification and enumeration; and during the first visit, a single 18.9-liter depth-integrated sample was composited for algal assays. Also each time, a depth-integrated sample was collected from each of the stations for chlorophyll a analysis. The maximum depths sampled were 1.5 meters at station 1, 9.4 meters at station 2, and 15.5 meters at station 3.

The lake sampling results are presented in full in Appendix D and are summarized in the following table.

A. SUMMARY OF PHYSICAL AND CHEMICAL CHARACTERISTICS FOR O'SHAUGNESSY RESERVOIR
STORET CODE 3931

PARAMETER	1ST SAMPLING (4/26/73) 3 SITES RANGE	MEAN	MEDIAN	2ND SAMPLING (8/ 2/73) 3 SITES RANGE	MEAN	MEDIAN	3RD SAMPLING (10/10/73) 3 SITES RANGE	MEAN	MEDIAN
TEMP (C)	8.7 - 15.7	13.6	14.7	14.6 - 24.8	21.3	22.9	14.8 - 20.1	18.3	18.7
DISS OXY (MG/L)	6.4 - 8.6	7.9	8.0	0.1 - 6.2	2.5	1.5	0.1 - 5.0	2.3	1.8
CNDCTVY (MCROMO)	425. - 625.	558.	580.	375. - 625.	459.	453.	403. - 686.	551.	566.
PH (STAND UNITS)	7.7 - 7.9	7.8	7.9	7.4 - 7.9	7.6	7.5	7.2 - 7.9	7.5	7.5
TOT ALK (MG/L)	128. - 202.	179.	189.	112. - 275.	170.	133.	116. - 260.	204.	203.
TOT P (MG/L)	0.162 - 0.286	0.191	0.174	0.124 - 0.295	0.216	0.222	0.174 - 1.020	0.397	0.238
ORTHO P (MG/L)	0.124 - 0.200	0.153	0.151	0.097 - 0.203	0.151	0.159	0.145 - 0.750	0.280	0.171
NO2+NO3 (MG/L)	2.700 - 3.500	3.000	3.000	1.340 - 4.750	3.786	4.160	0.040 - 2.390	1.061	1.210
AMMONIA (MG/L)	0.060 - 0.230	0.118	0.110	0.100 - 1.220	0.323	0.150	0.060 - 2.440	0.583	0.240
KJEL N (MG/L)	0.600 - 1.200	0.931	0.900	1.200 - 2.100	1.515	1.500	0.800 - 3.600	1.600	1.400
INORG N (MG/L)	2.930 - 3.640	3.118	3.080	2.560 - 5.430	4.109	4.370	1.230 - 2.630	1.644	1.290
TOTAL N (MG/L)	3.600 - 4.700	3.931	3.900	3.440 - 6.750	5.302	5.720	2.010 - 4.390	2.661	2.330
CHLRPYL A (UG/L)	3.2 - 9.6	6.1	5.6	2.2 - 4.4	3.4	3.5	2.4 - 15.9	7.1	2.9
SECCHI (METERS)	0.2 - 0.5	0.4	0.5	0.4 - 0.5	0.4	0.4	0.2 - 1.2	0.7	0.9

B. Biological characteristics:

1. Phytoplankton -

Sampling Date	Dominant Genera	Algal Units per ml
04/26/73	1. Flagellates	708
	2. Cryptomonas sp.	490
	3. Stephanodiscus sp.	272
	4. Synedra sp.	91
	5. Oscillatoria sp.	36
	Other genera	37
	Total	1,634
08/02/73	1. Cryptomonas sp.	195
	2. Stephanodiscus sp.	130
	3. Synedra sp.	86
	4. Melosira sp.	43
	5. Scenedesmus sp.	43
	Other genera	87
	Total	584
10/10/73	1. Euglena sp.	1,487
	2. Stephanodiscus sp.	178
	3. Flagellates	155
	4. Cryptomonas sp.	133
	5. Lepocinclis sp.	111
	Other genera	444
	Total	2,508

2. Chlorophyll *a* -

Sampling Date	Station Number	Chlorophyll *a* - (µg/l)
04/26/73	01	3.2
	02	5.6
	03	9.6
08/02/73	01	4.4
	02	2.2
	03	3.5
10/10/73	01	15.9
	02	2.9
	03	2.4

C. Limiting Nutrient Study:

The algal assay results are not indicative of conditions in the reservoir at the time the sample was taken (04/26/73) because of significant losses of nutrients during shipment from the field to the laboratory. The reservoir data indicate that primary production was limited by phosphorus during the early spring and summer; i.e., the mean inorganic nitrogen/ortho-phosphorus ratios were 20/1 on April 26, 1973, and 27/1 on August 2, 1973. During the fall sampling, the data indicate that nitrogen became limiting; i.e., the mean N/P ratio on October 10, 1973, was 6/1.

IV. NUTRIENT LOADINGS
(See Appendix E for data)

For the determination of nutrient loadings, the Ohio National Guard collected monthly near-surface grab samples from each of the tributary sites indicated on the map (page v), except for the high runoff months of February and March when two samples were collected. Sampling was begun in May, 1973, and was completed in April, 1974.

Through an interagency agreement, stream flow estimates for the year of sampling and a "normalized" or average year were provided by the Ohio District Office of the U.S. Geological Survey for the tributary sites nearest the lake.

In this report, nutrient loads for sampled tributaries were determined by using a modification of a U.S. Geological Survey computer program for calculating stream loadings*. Nutrient loads shown are those measured minus point-source loads, if any.

Nutrient loads for unsampled "minor tributaries and immediate drainage" ("ZZ" of U.S.G.S.) were estimated using the nutrient loads, in kg/km^2/year, at station C-1 and multiplying by the ZZ area in km^2.

The operator of the Marysville wastewater treatment plant provided monthly effluent samples and corresponding flow data. The communities of Marion and Richwood and the Girls Industrial School did not participate in the Survey, and nutrient loads were estimated at 1.134 kg P and 3.401 kg N/capita/year (the phosphorus load given for the Girls Industrial School is based on 80% removal). The septic tank nutrient loads from the

* See Working Paper No. 175.

towns of Prospect and Shawnee Hills were estimated at 0.1134 kg P and 4.263 kg N/capita/year.

A. Waste Sources:

1. Known municipal -

Name	Pop. Served	Treatment	Mean Flow (m^3/d)	Receiving Water
Marysville*	5,744	act. sludge	3,714.1	Mill Creek
Marion**	38,646	trickling filter	14,627.5	Little Scioto River
Richwood**	2,072	trickling filter	784.3	Fulton Creek
Girls Ind. Sch.***	700	secondary, P-removal	265.0	O'Shaughnessy Reservoir
Prospect	1,031	septic tanks	?	Scioto River
Shawnee Hills	428	septic tanks	?	O'Shaughnessy Reservoir

2. Known industrial - None

* Elkins, 1974 (population shown is 1970 Census; more than 25% of total waste load is from food processing industry; population equivalence of 12,000-15,000).
** Anonymous, 1971 (population shown is 1970 Census; flow estimated at 0.3785 m^3/capita/day).
*** Anonymous, 1975 (in operation for last two years); flow estimated at 0.3785 m^3/capita/day.

B. Annual Total Phosphorus Loading - Average Year:

1. Inputs -

Source	kg P/ yr	% of total
a. Tributaries (non-point load) -		
Scioto River	152,850	64.5
Mill Creek	24,660	10.4
Eversole Run	540	0.2
b. Minor tributaries & immediate drainage (non-point load) -	880	0.4
c. Known municipal STP's -		
Girls Industrial School	160	0.1
Marysville	11,420	4.8
Richwood	2,350	1.0
Marion	43,825	18.5
d. Septic tanks* -	195	0.1
e. Known industrial - None	-	-
f. Direct precipitation** -	60	<0.1
Total	236,940	100.0

2. Outputs -

Lake outlet - Scioto River 153.670

3. Net annual P accumulation - 83,270 kg.

* Estimate based on population of Prospect and Shawnee Hills plus 110 lakeshore dwellings; see Working Paper No. 175.
** See Working Paper No. 175.

C. Annual Total Nitrogen Loading - Average Year:

1. Inputs -

Source	kg N/ yr	% of total
a. Tributaries (non-point load) -		
Scioto River	2,621,835	79.3
Mill Creek	454,555	13.8
Eversole Run	20,580	0.6
b. Minor tributaries & immediate drainage (non-point load) -	34,030	1.0
c. Known municipal STP's -		
Girls Industrial School	2,380	0.1
Marysville	22,415	0.7
Richwood	7,045	0.2
Marion	131,435	4.0
d. Septic tanks* -	7,390	0.2
e. Known industrial - None	-	-
f. Direct precipitation** -	3,615	0.1
Total	3,305,280	100.0

2. Outputs -

Lake outlet - Scioto River 3,301,920

3. Net annual N accumulation - 3,360 kg.

* Estimate based on population of Prospect and Shawnee Hills plus 110 lakeshore dwellings; see Working Paper No. 175.
** See Working Paper No. 175.

D. Mean Annual Non-point Nutrient Export by Subdrainage Area:

Tributary	kg P/km²/yr	kg N/km²/yr
Scioto River	77	1,315
Mill Creek	53	980
Eversole Run	19	735

E. Yearly Loadings:

In the following table, the existing phosphorus loadings are compared to those proposed by Vollenweider (Vollenweider and Dillon, 1974). Essentially, his "dangerous" loading is one at which the receiving water would become eutrophic or remain eutrophic; his "permissible" loading is that which would result in the receiving water remaining oligotrophic or becoming oligotrophic if morphometry permitted. A mesotrophic loading would be considered one between "dangerous" and "permissible".

Note that Vollenweiders's model may not be applicable to water bodies with short hydraulic retention times.

	Total Phosphorus		Total Nitrogen	
	Total	Accumulated	Total	Accumulated
grams/m²/yr	70.73	24.86	986.7	1.0

Vollenweider phosphorus loadings (g/m²/yr) based on mean depth and mean hydraulic retention time of O'Shaughnessy Reservoir:

"Dangerous" (eutrophic loading)	2.66
"Permissible" (oligotrophic loading)	1.33

V. LITERATURE REVIEWED

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Youger, John, 1975. Personal communication (lake morphometry). OH Env. Prot. Agency, Columbus.

VI. APPENDICES

APPENDIX A

LAKE RANKINGS

LAKE DATA TO BE USED IN RANKINGS

LAKE CODE	LAKE NAME	MEDIAN TOTAL P	MEDIAN INORG N	500-MEAN SEC	MEAN CHLORA	15-MIN SD	MEDIAN DISS ORTHO P
3901	BEACH CITY RESERVOIR	0.122	1.490	489.000	10.867	11.600	0.015
3902	BUCKEYE LAKE	0.179	0.380	490.000	186.567	9.600	0.020
3905	CHARLES MILL RESERVOIR	0.127	0.465	482.555	67.144	15.000	0.011
3906	DEER CREEK RESERVOIR	0.098	2.980	470.125	9.887	13.900	0.036
3907	DELAWARE RESERVOIR	0.086	2.340	484.111	10.856	14.500	0.024
3908	DILLION RESERVOIR	0.163	1.590	481.250	27.400	14.300	0.037
3912	GRANT LAKE	0.113	0.570	486.333	40.533	12.200	0.019
3914	HOOVER RESERVOIR	0.040	1.640	462.750	13.017	14.800	0.008
3915	INDIAN LAKE	0.120	0.380	485.222	76.855	14.200	0.012
3917	LORAMIE LAKE	0.185	1.380	494.000	104.100	8.200	0.019
3921	MOSQUITO CREEK RESERVOIR	0.058	0.150	465.333	36.267	11.600	0.006
3924	PLEASANT HILL LAKE	0.036	0.455	456.833	22.850	14.700	0.010
3927	LAKE SAINT MARYS	0.148	0.200	484.167	79.150	8.200	0.014
3928	ATWOOD RESERVOIR	0.031	0.205	462.000	16.442	14.700	0.005
3929	BERLIN RESERVOIR	0.042	0.900	465.435	15.496	13.600	0.006
3930	HOLIDAY LAKE	0.125	0.575	465.333	55.350	15.000	0.034
3931	O'SHAUGNESSY RESERVOIR	0.208	3.070	479.333	5.522	14.900	0.159
3932	ROCKY FORK LAKE	0.067	0.790	473.000	38.022	15.000	0.010
3933	SHAWNEE LAKE	0.069	2.380	474.333	39.567	15.000	0.009
3934	TAPPAN LAKE	0.040	0.280	466.111	37.711	15.000	0.007

PERCENT OF LAKES WITH HIGHER VALUES (NUMBER OF LAKES WITH HIGHER VALUES)

LAKE CODE	LAKE NAME	MEDIAN TOTAL P	MEDIAN INORG N	500- MEAN SEC	MEAN CHLORA	15- MIN DO	MEDIAN DISS ORTHO P	INDEX NO
3901	BEACH CITY RESERVOIR	37 (7)	21 (4)	11 (2)	84 (16)	82 (15)	42 (8)	277
3902	BUCKEYE LAKE	11 (2)	76 (14)	5 (1)	0 (0)	89 (17)	26 (5)	207
3905	CHARLES MILL RESERVOIR	26 (5)	63 (12)	37 (7)	21 (4)	11 (0)	58 (11)	216
3906	DEER CREEK RESERVOIR	53 (10)	5 (1)	63 (12)	95 (18)	63 (12)	11 (2)	290
3907	DELAWARE RESERVOIR	58 (11)	16 (3)	32 (6)	89 (17)	47 (9)	21 (4)	263
3908	DILLION RESERVOIR	16 (3)	32 (6)	42 (8)	58 (11)	53 (10)	5 (1)	206
3912	GRANT LAKE	47 (9)	58 (11)	16 (3)	32 (6)	74 (14)	34 (6)	261
3914	HOOVER RESERVOIR	87 (16)	26 (5)	89 (17)	79 (15)	32 (6)	79 (15)	392
3915	INDIAN LAKE	42 (8)	76 (14)	21 (4)	16 (3)	58 (11)	53 (10)	266
3917	LORAMIE LAKE	5 (1)	37 (7)	0 (0)	5 (1)	97 (18)	34 (6)	178
3921	MOSQUITO CREEK RESERVOIR	74 (14)	100 (19)	82 (15)	53 (10)	82 (15)	92 (17)	483
3924	PLEASANT HILL LAKE	95 (18)	68 (13)	100 (19)	63 (12)	39 (7)	66 (12)	431
3927	LAKE SAINT MARYS	21 (4)	95 (18)	26 (5)	11 (2)	97 (18)	47 (9)	297
3928	ATWOOD RESERVOIR	100 (19)	89 (17)	95 (18)	68 (13)	39 (7)	100 (19)	491
3929	BERLIN RESERVOIR	79 (15)	42 (8)	74 (14)	74 (14)	68 (13)	92 (17)	424
3930	HOLIDAY LAKE	32 (6)	53 (10)	82 (15)	26 (5)	11 (0)	16 (3)	220
3931	O'SHAUGNESSY RESERVOIR	0 (0)	0 (0)	47 (9)	100 (19)	26 (5)	0 (0)	173
3932	ROCKY FORK LAKE	68 (13)	47 (9)	58 (11)	42 (8)	11 (0)	66 (12)	292
3933	SHAWNEE LAKE	63 (12)	11 (2)	53 (10)	37 (7)	11 (0)	74 (14)	249
3934	TAPPAN LAKE	87 (16)	84 (16)	68 (13)	47 (9)	11 (0)	84 (16)	381

LAKES RANKED BY INDEX NOS.

RANK	LAKE CODE	LAKE NAME	INDEX NO
1	3928	ATWOOD RESERVOIR	491
2	3921	MOSQUITO CREEK RESERVOIR	483
3	3924	PLEASANT HILL LAKE	431
4	3929	BERLIN RESERVOIR	429
5	3914	HOOVER RESERVOIR	392
6	3934	TAPPAN LAKE	381
7	3927	LAKE SAINT MARYS	297
8	3932	ROCKY FORK LAKE	292
9	3906	DEER CREEK RESERVOIR	290
10	3901	BEACH CITY RESERVOIR	277
11	3915	INDIAN LAKE	266
12	3907	DELAWARE RESERVOIR	263
13	3912	GRANT LAKE	261
14	3933	SHAWNEE LAKE	249
15	3930	HOLIDAY LAKE	220
16	3905	CHARLES MILL RESERVOIR	216
17	3902	BUCKEYE LAKE	207
18	3908	DILLION RESERVOIR	206
19	3917	LORAMIE LAKE	178
20	3931	O'SHAUGNESSY RESERVOIR	173

APPENDIX B

CONVERSION FACTORS

CONVERSION FACTORS

Hectares x 2.471 = acres

Kilometers x 0.6214 = miles

Meters x 3.281 = feet

Cubic meters x 8.107×10^{-4} = acre/feet

Square kilometers x 0.3861 = square miles

Cubic meters/sec x 35.315 = cubic feet/sec

Centimeters x 0.3937 = inches

Kilograms x 2.205 = pounds

Kilograms/square kilometer x 5.711 = lbs/square mile

APPENDIX C

TRIBUTARY FLOW DATA

TRIBUTARY FLOW INFORMATION FOR OHIO 1/27/75

LAKE CODE 3931 OSHAUGHNESSY RESERVOIR

TOTAL DRAINAGE AREA OF LAKE(SQ KM) 2535.6

TRIBUTARY	SUB-DRAINAGE AREA(SQ KM)	NORMALIZED FLOWS(CMS) JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	MEAN
3931A1	1994.3	27.47	29.17	44.17	35.68	21.44	14.61	8.52	4.11	3.65	4.87	8.50	15.60	18.09
3931A2	2535.6	38.74	38.51	49.27	40.49	23.22	17.95	8.66	6.31	4.98	4.67	7.84	18.46	21.50
3931B1	463.6	8.16	8.24	10.28	8.07	4.22	3.68	0.99	0.88	0.51	0.42	1.59	3.34	4.17
3931C1	28.0	0.40	0.48	0.71	0.57	0.34	0.18	0.12	0.06	0.04	0.05	0.10	0.23	0.27
3931Z2	49.7	0.71	0.85	1.22	0.99	0.57	0.34	0.21	0.10	0.07	0.09	0.19	0.40	0.48

SUMMARY

TOTAL DRAINAGE AREA OF LAKE = 2535.6
SUM OF SUB-DRAINAGE AREAS = 2535.6

TOTAL FLOW IN = 277.16
TOTAL FLOW OUT = 259.18

MEAN MONTHLY FLOWS AND DAILY FLOWS(CMS)

TRIBUTARY	MONTH	YEAR	MEAN FLOW	DAY	FLOW	DAY	FLOW	DAY	FLOW
3931A1	5	73	18.63	5	15.80				
	6	73	20.47	4	7.96				
	7	73	22.46	10	8.86				
	8	73	24.55	4	5.32				
	9	73	2.01	8	1.56				
	10	73	4.05	13	2.86				
	11	73	15.77	3	8.07				
	12	73	33.41	1	64.28				
	1	74	73.28	5	13.34				
	2	74	25.85	2	26.82	17	17.56		
	3	74	31.71	2	38.51	19	25.06		
	4	74	36.25	6	101.37				
3931A2	5	73	23.36	5	21.27				
	6	73	27.41	4	10.51				
	7	73	25.77	10	10.42				
	8	73	28.60	4	6.77				
	9	73	2.83	8	3.14				
	10	73	3.65	13	3.65				
	11	73	22.48	3	10.68				
	12	73	42.75	1	68.81				
	1	74	100.52	5	16.31				
	2	74	32.00	2	36.25	17	22.51		
	3	74	40.21	2	47.56	19	35.96		
	4	74	49.55	6	111.29				

TRIBUTARY FLOW INFORMATION FOR OHIO 1/27/75

LAKE CODE 3931 OSHAUGHNESSY RESERVOIR

MEAN MONTHLY FLOWS AND DAILY FLOWS(CMS)

TRIBUTARY	MONTH	YEAR	MEAN FLOW	DAY	FLOW	DAY	FLOW	DAY	FLOW
393181	5	73	2.83	5	3.57				
	6	73	6.54	4	2.07				
	7	73	2.49	10	0.79				
	8	73	3.40	4	0.85				
	9	73	0.45	8	0.40				
	10	73	0.71	13	0.37				
	11	73	6.20	3	1.59				
	12	73	7.82	1	6.54				
	1	74	14.70	5	2.44				
	2	74	6.88	2	4.84	17	4.16		
	3	74	7.33	2	8.61	19	4.11		
	4	74	7.96	6	7.28				
3931C1	5	73	0.65	5	0.34				
	6	73	0.25	4	0.82				
	7	73	0.31	10	0.19				
	8	73	0.22	4	0.06				
	9	73	0.03	8	0.03				
	10	73	0.08	13	0.02				
	11	73	0.40	3	0.11				
	12	73	0.54	1	0.45				
	1	74	0.88	5	0.14				
	2	74	0.42	2	0.31	17	0.26		
	3	74	0.45	2	0.54	19	0.25		
	4	74	0.48	6	0.45				
393122	5	73	1.10						
	6	73	0.48						
	7	73	0.54						
	8	73	0.40						
	9	73	0.07						
	10	73	0.15						
	11	73	0.74						
	12	73	0.93						
	1	74	1.59						
	2	74	0.74						
	3	74	0.79						
	4	74	0.85						

APPENDIX D

PHYSICAL and CHEMICAL DATA

STORET RETRIEVAL DATE 75/01/27

393101
40 14 42.0 083 08 47.0
O'SHAUGNESSY RESERVOIR
39041 OH10

11EPALES
3

2111202
0005 FEET DEPTH

DATE FROM TO	TIME OF DAY	DEPTH FEET	00010 WATER TEMP CENT	00300 DO MG/L	00077 TRANSP SECCHI INCHES	00094 CNDUCTVY FIELD MICROMHO	00400 PH SU	00410 T ALK CACO3 MG/L	00610 NH3-N TOTAL MG/L	00625 TOT KJEL N MG/L	00630 NO2&NO3 N-TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P
73/04/26	11 45	0000	12.6	8.6	8	600	7.80	192	0.140	1.200	3.500	0.200
73/08/02	11 00	0000	23.0		17	623	7.90	270	0.120	1.300	2.900	0.203
	11 00	0005	22.7	6.2		625	7.90	275	0.120	1.300	2.860	0.192
73/10/10	15 10	0000	17.9	5.0	6	403	7.70	116	0.240	2.000	2.390	0.456
	15 10	0005	17.2			443						

DATE FROM TO	TIME OF DAY	DEPTH FEET	00665 PHOS-TOT MG/L P	32217 CHLRPHYL A UG/L
73/04/26	11 45	0000	0.286	3.2
73/08/02	11 00	0000	0.293	4.4
	11 00	0005	0.295	
73/10/10	15 10	0000	0.810	15.9

STORET RETRIEVAL DATE 75/01/27

393102
40 11 22.0 083 08 03.0
O'SHAUGHNESSY RESERVOIR
39041 OHIO

11EPALES
3

2111202
0035 FEET DEPTH

DATE FROM TO	TIME OF DAY	DEPTH FEET	00010 WATER TEMP CENT	00300 DO MG/L	00077 TRANSP SECCHI INCHES	00094 CNDUCTVY FIELD MICROMHO	00400 PH SU	00410 T ALK CACO3 MG/L	00610 NH3-N TOTAL MG/L	00625 TOT KJEL N MG/L	00630 NO2&NO3 N-TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P
73/04/26	14	05 0000	14.9		20	600	7.80	193	0.110	1.200	3.000	0.161
	14	05 0006	14.7	8.0		600	7.90	192	0.110	0.900	3.000	0.161
	14	05 0015	14.2	6.4		625	7.90	202	0.140	0.900	3.000	0.170
	14	05 0022	13.8	7.6		600	7.90	197	0.130	0.900	3.000	0.164
	14	05 0031	10.6	7.4		470	7.70	143	0.170	0.900	3.000	0.130
73/08/02	10	20 0000	24.3	4.8	17	401	7.70	126	0.160	1.500	4.160	0.171
	10	20 0005	24.2	4.8		412	7.60	131	0.150	1.500	4.220	0.173
	10	20 0010	24.1			409						
	10	20 0015	23.3	2.1		400	7.50	127	0.100	1.500	4.500	0.161
	10	20 0020	22.8	0.9		410	7.40	133	0.110	1.500	4.480	0.137
	10	20 0025	21.4			493						
	10	20 0030	18.1	0.2		569	7.50	200	0.680	2.000	4.750	0.120
73/10/10	15	25 0000	20.1	4.4	36	578	7.90	201	0.060	1.100	1.230	0.168
	15	25 0015	14.5	0.6		575	7.50	203	0.080	0.800	1.210	0.145
	15	25 0030	10.8	3.8		686	7.50	218	0.530	1.600	1.360	0.750

DATE FROM TO	TIME OF DAY	DEPTH FEET	00665 PHOS-TOT MG/L P	32217 CHLRPHYL A UG/L
73/04/26	14	05 0000	0.206	5.6
	14	05 0006	0.187	
	14	05 0015	0.216	
	14	05 0022	0.194	
	14	05 0031	0.174	
73/08/02	10	20 0000	0.238	2.2
	10	20 0005	0.227	
	10	20 0015	0.230	
	10	20 0020	0.222	
	10	20 0030	0.174	
73/10/10	15	25 0000	0.218	2.9
	15	25 0015	0.193	
	15	25 0030	1.020	

72

STORET RETRIEVAL DATE 75/01/27

393103
40 09 25.0 083 07 37.0
O'SHAUGNESSY RESERVOIR
39041 OHIO

11EPALES
3

2111202
0053 FEET DEPTH

DATE FROM TO	TIME OF DAY	DEPTH FEET	00010 WATER TEMP CENT	00300 DO MG/L	00077 TRANSP SECCHI INCHES	00094 CNDUCTVY FIELD MICROMHO	00400 PH SU	00410 T ALK CACO3 MG/L	00610 NH3-N TOTAL MG/L	00625 TOT KJEL N MG/L	00630 NO2&NO3 N-TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P
73/04/26	14	35 0000	15.7		18	580	7.90	189	0.070	0.700	3.000	0.150
	14	35 0006	15.7	8.6		580	7.90	189	0.060	0.600	3.000	0.151
	14	35 0015	15.7	8.4		580	7.90	188	0.070	1.000	3.000	0.156
	14	35 0022	15.7	8.0		570	7.90	189	0.070	0.900	3.000	0.149
	14	35 0030	15.1	8.0		580	7.90	188	0.080	0.800	3.000	0.148
	14	35 0040	9.0	4.3		425	7.80	128	0.160	1.000	2.800	0.124
	14	35 0049	8.7	7.3		440	7.70	134	0.230	1.100	2.700	0.128
73/08/02	09	35 0000	24.8	5.2	18	376	7.70	115	0.160	1.700	4.140	0.162
	09	35 0005	24.7			382						
	09	35 0010	24.6			380						
	09	35 0015	24.3	4.4		375	7.40	112	0.130	1.300	4.540	0.159
	09	35 0020	23.2	0.9		401	7.40	122	0.110	1.200	4.690	0.151
	09	35 0025	20.4	0.5		508	7.50	175	0.460	1.300	4.060	0.133
	09	35 0030	17.4	0.3		498	7.50	198	0.680	1.500	2.580	0.109
	09	35 0035	16.6			496						
	09	35 0040	15.8			494						
	09	35 0045	15.4			494						
	09	35 0050	14.6	0.1		495	7.40	220	1.220	2.100	1.340	0.097
73/10/10	16	30 0000	14.8	4.4	46	558	7.80	200	0.070	0.900	1.190	0.154
	16	30 0015	19.4	1.8		560	7.50	201	0.080	0.800	1.210	0.146
	16	30 0027	18.0	0.1		578	7.40	212	0.620	1.400	0.610	0.171
	16	30 0040	17.2	0.1		553	7.40	226	1.130	2.200	0.310	0.205
	16	30 0051	14.8	0.2		571	7.20	260	2.440	3.600	0.040	0.328

STORET RETRIEVAL DATE 75/01/27

393103
40 09 25.0 083 07 37.0
O'SHAUGNESSY RESERVOIR
39041 OHIO

11EPALES 2111202
3 0053 FEET DEPTH

DATE FROM TO	TIME OF DAY	DEPTH FEET	00665 PHOS-TOT MG/L P	32217 CHLRPHYL A UG/L
73/04/26	14 35	0000	0.170	4.6
	14 35	0006	0.168	
	14 35	0015	0.158	
	14 35	0022	0.164	
	14 35	0030	0.169	
	14 35	0040	0.162	
	14 35	0049	0.208	
73/08/02	09 35	0000	0.220	3.5
	09 35	0015	0.218	
	09 35	0020	0.224	
	09 35	0025	0.201	
	09 35	0030	0.141	
	09 35	0050	0.124	
73/10/10	16 30	0000	0.174	2.4
	16 30	0015	0.181	
	16 30	0027	0.238	
	16 30	0040	0.268	
	16 30	0051	0.453	

APPENDIX E

TRIBUTARY and WASTEWATER TREATMENT PLANT DATA

STORET RETRIEVAL DATE 75/02/03

3931A1
40 17 20.0 083 09 35.0
SCIOTO RIVER
39 7.5 OSTRANDER
1/OSHAUGHNESSY RES
US 36 BRDG .7 MI N OF WHITE SULPHUR
11EPALES 2111204
4 0000 FEET DEPTH

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO2&NO3 N-TOTAL MG/L	00625 TOT KJEL N MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P
73/05/05	13 15		3.400	1.600	0.070	0.200	0.275
73/06/04	12 50		0.010K	0.910	0.006	0.005K	0.390
73/07/10	19 10		4.800	1.760	0.132	0.210	0.270
73/08/04	14 30		2.300	0.810	0.056	0.270	0.330
73/09/08	15 00		0.010K	0.380	0.043	0.220	0.440
73/10/13	14 37		2.700	1.400	0.057	0.490	0.640
73/11/03	14 50		3.600	1.300	0.104	0.430	0.530
73/12/01	14 40		6.400	1.600	0.060	0.168	0.370
74/02/02	14 00		4.000	1.100	0.110	0.110	0.210
74/02/17	17 43		3.600	0.900	0.100	0.145	0.230
74/03/02	14 25		4.100	1.100	0.135	0.120	0.260
74/03/19	16 45		4.800	1.600	0.085	0.120	0.260
74/04/06	14 35		3.000	3.100	0.055	0.090	

K VALUE KNOWN TO BE
LESS THAN INDICATED

STORET RETRIEVAL DATE 75/02/10

393142
40 09 14.0 083 07 35.0
SCIOTO RIVER
39 7.5 SHAWNEE HILL
O/OSHAUGHNESSY RES
OSHAUGHNESSY DAM
11EPALES 2111204
4 0000 FEET DEPTH

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO2&NO3 N-TOTAL MG/L	00625 TOT KJEL N MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P
73/05/05	12 25		3.000	1.900	0.140	0.126	0.190
73/06/04	12 15		0.010K	0.920	0.012	0.102	0.165
73/07/10	18 23		6.900	2.310	0.360	0.126	0.210
73/08/04	13 40		3.400	2.300	0.052	0.147	0.270
73/09/08	14 05		0.920	1.600	0.080	0.068	0.160
73/10/13	13 55		1.200	0.950	0.065	0.173	0.200
73/11/03	14 55		1.520	0.900	0.048	0.184	0.230
73/12/01	15 25		5.700	1.400	0.092	0.184	0.390
74/01/05	13 20		6.000	1.200	0.095	0.118	0.200
74/02/02	13 25		2.700	0.900	0.090	0.075	0.260
74/02/17	17 10		3.300	0.900	0.125	0.140	0.195
74/03/02	13 50		4.800	1.200	0.150	0.125	0.250
74/03/19	16 15		3.800	1.100	0.125	0.135	0.220
74/04/06	13 55		3.000	2.600	0.145	0.105	

K VALUE KNOWN TO BE
LESS THAN INDICATED

3/

STORET RETRIEVAL DATE 75/02/03

393181
40 14 44.0 083 09 10.0
MILL CREEK
39 7.5 SHAWNEE HILL
T/OSHAUGHNESSY RES
ST HWY 257/745 BRDG AT BELLEPOINT
11EPALES 2111204
4 0000 FEET DEPTH

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO2&NO3 N-TOTAL MG/L	00625 TOT KJEL N MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P
73/05/05	13 00		1.640	1.980	0.039	0.092	0.180
73/06/04	12 45		0.010K	0.800	0.018	0.005K	0.330
73/07/10	18 53		4.400	1.815	0.130	0.231	0.345
73/08/04	14 20		1.880	1.300	0.220	0.240	0.310
73/09/03	14 45		0.220	2.500	0.069	0.231	0.350
73/10/13	14 30		1.040	0.900	0.046	0.370	0.390
73/11/03	14 40		3.400	1.350	0.072	0.330	0.400
73/12/01	14 25		3.700	1.000	0.056		0.210
74/02/02	13 50		2.300	0.500	0.150	0.115	0.190
74/02/17	17 35		1.900	0.900	0.085	0.110	0.190
74/03/02	14 20		2.600	1.100	0.065	0.075	0.220
74/03/19	16 40		2.200	0.800	0.030	0.080	0.175
74/04/06	14 25		1.800	1.900	0.165	0.095	0.290

K VALUE KNOWN TO BE
LESS THAN INDICATED

STORET RETRIEVAL DATE 75/02/03

3931C1
40 10 50.0 083 08 55.0
EVERSOLE RUN
39 7.5 SHAWNEE HILL
T/OSHAUGHNESSY RES
2NDRY RD BRDG .5 MI W OF ST HWY 745
11EPALES 2111204
4 0000 FEET DEPTH

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO2&NO3 N-TOTAL MG/L	00625 TOT KJEL N MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P
73/05/05	12 45		1.500	0.460	0.014	0.007	0.015
73/06/04	12 33		0.010K	0.890	0.055	0.013	0.040
73/07/10	18 40		1.100	1.700	0.220	0.046	0.080
73/08/04	14 05		0.300	0.840	0.100	0.024	0.042
73/09/05	14 25		0.160	2.300	0.180	0.025	0.042
73/10/13	14 10		0.066	0.375	0.021	0.025	0.050
73/11/03	14 25		4.800	1.200	0.036	0.052	0.065
73/12/01	14 10		3.080	0.800	0.024	0.048	0.135
74/01/05	13 40		1.900	0.300	0.024	0.016	0.030
74/02/02	13 35		1.600	0.300	0.025	0.020	0.040
74/02/17	17 21		1.090	0.300	0.020	0.020	0.035
74/03/02	14 00		2.100	0.700	0.020	0.025	0.075
74/03/19	16 25		0.900	0.500	0.015	0.015	0.035
74/04/06	14 10		1.760	1.600	0.065	0.055	0.200

K VALUE KNOWN TO BE
LESS THAN INDICATED

STORET RETRIEVAL DATE 75/02/03

3931BA AS3931BA P014000*
40 14 30.0 083 21 50.0
MARYSVILLE
39151 UNION COUNTY
T/O*SHAUGHNESSY RESERVOI
MILL CREEK
11EPALES 2141204
4 0000 FEET DEPTH

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO2&NO3 N-TOTAL MG/L	00625 TOT KJEL N MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P	50051 FLOW RATE INST MGD	50053 CONDUIT FLOW-MGD MONTHLY
73/08/23	11 00								
CP(T)-			0.252	14.700	3.000	8.400		0.998	0.989
73/08/23	16 00								
73/09/21	11 00								
CP(T)-			0.068	10.600	3.950	6.730	7.600	0.917	1.120
73/09/21	16 00								
73/11/19	11 00								
CP(T)-			0.120	18.500	6.950	8.750	9.550	0.875	1.060
73/11/19	14 00								
73/12/06	11 00								
CP(T)-			0.210	17.500	4.700	5.500	6.000	0.940	1.130
73/12/06	15 00								
74/02/25	09 00								
CP(T)-			0.320	12.000	2.200	7.000	7.550	1.000	1.100
74/02/25	16 00								
74/03/21	09 00								
CP(T)-			0.320	12.000	3.200	5.900	7.400	1.020	0.970
74/03/21	14 00								
74/04/24	10 00								
CP(T)-			0.240	19.000	6.300	6.800	9.100	0.911	0.980
74/04/24	14 00								
74/05/14	10 00								
CP(T)-			0.040	19.000	6.900	8.900	9.600	0.859	0.991
74/05/14	14 00								
74/07/26	10 30		0.200	19.000	7.000	8.100	10.000	0.883	0.867
74/08/27	10 00								
CP(T)-			0.924	15.000	3.050	4.200	9.900	0.925	0.795
74/08/27	14 00								
74/10/09	10 00								
CP(T)-			0.080	21.000	10.000	7.000	8.400	0.840	0.847
74/10/10	14 00								
74/11/15	10 30								
CP(T)-			0.240	19.000	7.700	7.300	8.000	0.831	0.925
74/11/15	14 30								